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The Cost of Capital and Investment in Developing Countries

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A model for evaluating how policy changes might affect incentives to invest in developing countries.

This paper — a product of the Public Economics Division, Country Economics Department — is part of a larger effort in PRE to promote sound public policies in the development of the private sector in developing countries. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Ann Bhalla, room N10-059, extension 37699 (43 pages).

Auerbach's model can be used to evaluate how current and new policies might affect incentives to invest in a developing country.

It takes into account factors that are often ignored in analyses of investment in more developed countries — such factors as risk, foreign tax provisions that affect capital flows, the prevalence of trade distortions, the lack of domestic capital markets, and the relative credibility of government policy changes.

The author reviews the literature on investment and the cost of capital, showing how the effects of tax and nontax government policies should be incorporated in any analysis of investment behavior.

The methodology is more general than calculations of tax wedges and effective tax rates. It should help developing countries measure the efficacy of current policies, predict how policy changes may influence investment, and determine appropriate directions for reform.

This paper is the first in a series of papers commissioned by the Tax Incentives for Industrial and Technological Development Research Project of the Public Economics Division. Researchers on this project have focused on the following questions:

For each dollar of forgone tax revenues, how much have tax incentives stimulated investment?

Do taxes affect foreign investment in developing countries? Do they influence foreign business locations? If they do, what instruments best stimulate the most investment per dollar of tax revenues lost to the host country?

How do taxes affect industrial production? How have tax instruments affected the use of labor? How have they affected physical, research, and development capital?

How have business taxes and tax expenditures (forgone revenues) affected technological change, the expansion of private output, and after-tax profits?

Are these tax-induced distortions preventing firms from holding optimal levels of fixed factors?

Given the empirical estimates obtained in this study on factor substitution, a bias toward technical change, and scale economies, what revenue-neutral alternative tax policy environment would encourage growth and productivity?

THE COST OF CAPITAL AND INVESTMENT IN DEVELOPING COUNTRIES

by

Alan Auerbach

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I. Introduction

For governments in developing countries, an important policy objective is the creation of an environment that attracts capital to high-return fixed investment projects. Like more advanced countries, these economies seek the increases in labor productivity and living standards that capital deepening brings. For many reasons, however, the design of government policy toward investment in less developed countries is both more critical and more complex.

First, such countries may lack fully functioning internal capital markets, making it difficult to measure the cost of capital for new projects. Second, the inadequacy of domestic capital may force a significant dependence on foreign direct investment, which requires a more complete involvement on the part of the investor than simply supplying funds. Third, such countries typically impose more significant trade and production distortions in the form of excise taxes, tariffs, quotas and restrictions, for which account must be taken in estimating the incentives facing a potential investment. Fourth, certain types of investment incentives require an administrative infrastructure that may be absent in all but the most developed countries. Finally, the governments in these countries may lack the credibility needed to convince investors to respond to an announced change in policy.

Though the problems of policy design are considerable, so are the potential social returns from an appropriate investment climate. This paper develops measures of the incentive to invest that can be used to evaluate existing policies and guide the design of new ones, taking account of the complications just mentioned. The next section introduces the basic notation and modelling assumptions, while subsequent sections develop the model and its implications more fully.

II. The Model

A. The User Cost of Capital

To evaluate the incentive to invest, we consider the decisions of a firm that uses a single capital input, labor and intermediate inputs in the production process. The simplifying assumptions that capital and labor are homogeneous are not critical for most purposes of analysis. Initially, we will also assume that the firm's investments are riskless, and that it faces a constant tax system with full loss offset, has perfect certainty about the future, may adjust capital instantaneously, and is perfectly competitive (i.e. takes all prices as given). Though these restrictions are often made in analyzing investment incentives, they influence the results considerably and are particularly inappropriate in the present context. They are imposed initially for purposes of exposition and to permit a comparison of this paper's approach to those found elsewhere.

The model's notation is summarized in Table 1. We examine a firm that produces gross output X using capital, K, labor, L and inputs M according to the following relationship:

$$(1) \qquad X = X(K,L,M)$$

where $X(\cdot)$ is a general production function with nonincreasing returns to scale.

Let r be the real discount rate that the firm uses in valuing future cash flows from the investment project. As discussed in Auerbach (1983b), this may be constructed as a weighted average of the real costs of debt and equity finance. For example, in a closed economy without an indexed tax system, the formula for r would be:

$$(2) \qquad r = b[i(1-\tau) - \pi] + (1-b)\mu/(1-\Phi)$$

where i is the nominal interest rate, τ is the corporate tax rate against which interest payments are normally tax deductible, μ is the real discount rate of equity-holders, Φ is the tax rate effectively applied to real equity returns, π is the inflation rate, and b is the fraction of the project financed with debt. The construction of this measure depends on a number of institutional factors, such as the source of marginal equity funds, for this determines the extent to which the tax rate on dividends actually exerts a marginal impact. In less developed countries, calculation of the relevant interest rate, as well as the importance of foreign investors, may be more significant questions. These issues are discussed further below. For the moment, the analysis simply takes the determination of r as given. Let the prices of output, materials and capital goods that the company faces be p, v and g, respectively, and let w be the wage rate. Because of taxes and other distortions in product and factor markets, these will not necessarily be observed "market" prices. They should simply be interpreted as the effective marginal prices that firms face for the associated commodities.

Let Γ be the present value of the after-tax cash flow attributable to depreciation allowances, investment grants and investment tax credits received by the firm per dollar of new investment. That is, if grants and credits k are received immediately and depreciation deductions D(t-s) are received at each date t after the initial investment at date s, then

$$(3) \qquad \Gamma = k + \tau z = k + \int_s^\infty \tau e^{-(r+\pi)(t-s)} D(t-s)\, dt$$

There are many types of investment incentives used in practice. Though some are more complicated, most can be expressed using this framework. This is discussed below.

The corporation's problem of maximizing the wealth of its shareholders at date s may then be shown (Auerbach 198?) to be equivalent to maximizing:

$$(4) \qquad V_s = \int_s^\infty e^{-(r+\pi)(t-s)} \{(1-\tau)[p_t X(K_t,L_t,M_t) - w_t L_t - v_t M_t] - g_t(1-\Gamma)I_t\}dt$$

where I_t is the firm's investment at date t. Under the familiar assumption that capital decays exponentially at rate δ, the evolution of the capital stock obeys the expression:

$$(5) \qquad \dot{K}_t = I_t - \delta K_t$$

The firm chooses I, L, and M at each date after t in order to maximize the function V_s. In order to focus on the investment decision, it will sometimes be useful to consider this decision conditional on the optimal decisions with respect to labor and material inputs. Since each is a variable factor of production, the optimization produces for each yields the standard rule of setting equal contemporaneous marginal revenues and costs at each date $t > s$:

$$(6) \qquad X_{Lt} = w_t/p_t$$

$$(7) \qquad X_{Mt} = v_t/p_t$$

The decision rules (6) and (7) provide two equations in the variables L, M and K. Hence, they may be used to define L and M implicitly in terms of K. That is, from (5) and (7) we may obtain expressions:

$$(8) \qquad L^* = L(K,\ w/p,\ v/p)$$

$$(9) \qquad M^* = M(K,\ w/p,\ v/p)$$

which may be used to obtain a production function of K alone:

$$(10) \qquad F_t(K) = X(K, L^*, M^*) - \left(\frac{w}{p}\right)_t L_t^* - \left(\frac{v}{p}\right)_t M_t^*$$

A time subscript must be attached to the new function $F(\cdot)$ because of its dependence on the real wage w/p and the real price of materials v/p.

Using the function $F_t(\cdot)$, we may rewrite the firm's optimization problem at date s as:

$$(11) \qquad \max V_s = \int_s^\infty e^{-(r+\pi)(t-s)} \{(1-\tau)p_t F_t(K_t) - g_t(1-\Gamma)(\dot{K}_t+\delta K_t)\}\, dt$$

which yields the Euler equation familiar from the literature.

$$(12) \qquad F_t'(K_t) = \frac{g_t(r+\delta)\ (1-\Gamma)}{p_t(1-\tau)}$$

The right-hand side of (12) has traditionally been called the <u>user cost of capital</u> (e.g. Jorgenson 1963), for it defines the shadow price to which the marginal product of capital should be set equal. However, with other factors of production the desired capital stock is a function of all input prices, not just the direct input price of capital. Thus, if one is interested in knowing the capital stock itself, rather than its marginal product, an alternative formulation of the user cost will prove more useful.

For purposes of exposition, let us assume that $F_t(\cdot)$ has the separable form:[1]

$$F_t(K) = \theta(w_t/p_t,\ v_t/p_t)G(K) = \theta_t G(K) \tag{13}$$

Then, the first-order condition (12) may be rewritten:

$$G'(K_t) = c_t = \frac{g_t(r + \delta)(1-\Gamma)/(1-\tau)}{\theta_t p_t} \tag{14}$$

Because of the assumption that the firm can adjust its capital stock instantaneously, expression (14) is a solution for the capital stock at date t and, given the initial capital stock, the rate of investment as well.[2] Therefore, since the function $G(\cdot)$ is time-invariant, the right-hand side of (14) represents a sufficient statistic for the incentive to use capital in production. We may think of this as the "full" user cost of capital. It incorporates effects on investment working directly through the effective rental price of capital as well as indirectly through the costs of other factors of production.

B. The Effective Tax Rate

Many researchers (e.g. Auerbach 1983a, King and Fullerton 1984) have found it useful to summarize the effects of the tax system on investment through an "effective tax rate" calculation. Though most of the literature has focused on developed countries, the approach has also been carefully applied in the development context (Pellechio 1987). The thought experiment giving rise to this measure is to ask what rate of tax applied to a broad-based income measure would lead to the same wedge between after-tax and before-tax returns as is actually observed. Put differently, for a given user cost of capital, what rate of tax on broad-based or "true economic" income would lead to the observed after-tax return.

Despite its apparent simplicity, the concept does not give rise to a unique definition, with the measure depending on which taxes are included in the calculation and what level of after-tax or before-tax rate of return is used as a benchmark. Moreover, the calculation of an effective tax rate alone does not provide enough information to infer the effects of tax policy on investment. Since the user cost of capital will result from adding the tax wedge to the after-tax rate of return, it is important to know not only how big the tax wedge is but to what extent it leads to a higher before-tax return rather than a lower after-tax return. Even in small open economies that must take world prices and rates of return as given, not all taxes will necessarily be fully reflected in a higher cost of capital. Some will be borne by imperfectly mobile factors (such as land and labor). Even with perfect capital mobility some capital income taxes may be shifted abroad if they are credited by foreign governments.

In spite of these limitations, the effective tax rate concept is a popular one that can be useful for certain purposes, particularly in comparing the <u>relative</u> incentive to invest in different assets. Therefore, we will describe in somewhat more detail how it fits into the current framework.

One may think of the total tax wedge affecting the return to capital as being divided into two parts. The first is the wedge between the required rate of return r and the corporation's return before tax. The second is the wedge between r and the return to investors after <u>all</u> taxes. The first wedge is the effective rate of corporate tax, indicating how provisions directly affecting investment affect the corporate tax base. One may also think of this as the effective rate of tax at the corporate level for an equity-financed investment, ignoring any provisions permitting a deduction for dividends paid.

To calculate the effective corporate tax rate, one would estimate how the tax rate τ in expression (14) would need to change to offset the repeal of investment incentives and the imposition of a system of economic depreciation allowances. This would involve varying τ to offset the replacement of Γ with the present value of economic depreciation deductions, $\tau\delta/(r+\delta)$, holding all other terms in the expression fixed. The resulting effective tax rate expression is (see Auerbach 1983a):

$$e_c = \frac{[(r+\delta)(1-\Gamma)/(1-\tau) - \delta] - r}{(r+\delta)(1-\Gamma)/(1-\tau) - \delta} \tag{15}$$

where the denominator is the before-tax return to capital (equal to the before-tax rate of return, net of actual depreciation) and the numerator is the "tax wedge" between this return and the corporate cost of funds r. This expression provides the standard results that immediate write-off of assets ($\Gamma=\tau$) leads to a zero effective tax rate and that with economic depreciation allowances (for which $\Gamma=\delta/(r+\delta)$), $e_c = \tau$.

A more comprehensive effective tax rate measure (see King and Fullerton 1984) is one that accounts not only for investment-oriented provisions at the corporate level, but also the second wedge discussed above, between the rate of return to firms after corporate taxes and the rate of return to savers. This second wedge would account for interest deductibility at the corporate level and taxes paid by individuals or other entities receiving the corporate-source income. To get a total wedge equal to the sum of the two wedges, one would add to the gap between the before-tax corporate return and the corporate cost of funds r the gap between r and the rate of return to suppliers of funds, say s.

To calculate this total effective tax rate, one must express r in terms of the net return to savers. This is achieved by substituting expression (2) into equation (14) and further expressing the interest rate i in terms of the net real return to bondholders, say n, and the income tax rate on interest received, say t_p:

$$i = (n+\pi)/(1-t_p) \tag{16}$$

The result is an expression for r in terms off the underlying real returns to equity and debt after all taxes, μ and n, that can be substituted into (15) to determine the total effective tax rate that encompasses the tax provisions embodied in Γ, the corporate tax rate τ and the individual tax rates Φ and t_p Contrary to the previous case, one would measure the tax wedge relative to μ and n rather than r. Here the calculation depends on which of a variety of assumptions one makes concerning the relationship of the two net rates of return, μ and n. The choice depends on which concept of financial equilibrium one chooses (King and Fullerton 1984). For the "fixed s" case in which these net returns are assumed to be equal (i.e., $\mu = n = s$)[3], this broader effective tax rate equals:

$$e_T = \frac{[(r+\delta)(1-\Gamma)/(1-\tau) - \delta] - s}{(r+\delta)(1-\Gamma)/(1-\tau) - \delta} \tag{17}$$

The numerator of (17) is the "total" tax wedge, incorporating the effects of interest deductibility and personal taxes that manifest themselves through the relationship of the corporation's cost of funds r and the net return to asset owners, s.

The effective tax rate e_T describes the total tax burden on domestic investment, domestically financed. In a closed economy, it would therefore be informative about the impact of the tax system on investment. In such an economy, there is no distinction between taxes on saving and taxes on investment. In a world with open economies, however, saving and investment may occur in different places. Policies aimed at encouraging saving in a country need not encourage investment there, but may simply cause more capital to flow abroad. To the extent that the marginal investor supplies funds from abroad, a different calculation that distinguishes taxes on saving and investment may be necessary.

One approach would be to consider the tax treatment of equity and debt owned by foreigners, and include these in the calculation as well. For example, Andersson _et al_ (1990) calculate the effective tax rates e_T for investment in the United States financed not only by domestic debt and equity funds, but also by debt and equity supplied via portfolio investment from Japan. They likewise calculate the effective tax rates on Japanese investment financed in Japan and from the United States.

The basic question to be addressed is how the firm's cost of funds r relates to the required returns to equity and debt μ and n when such funds come from abroad. (For a small developing economy, the returns μ and n may be taken as fixed, so that the associated gap between the net returns μ and n and the gross return r translates directly into a higher cost of capital.)

The answer to this question depends on both the host country's tax treatment of such capital flows as well as the home country's mechanism for crediting foreign taxes paid. This, in turn, depends on the type of entity that is supplying the capital, for foreign direct investment by corporations is treated differently than portfolio investment by individuals. Although Andersson _et al_ treat the case of portfolio investment, foreign direct investment and investment via financial intermediaries represent a more significant portion of the flows between the United States and Japan. This must be even more true of the capital flows into most developing countries.

It therefore seems most appropriate to consider the case in which the investment is by a foreign corporation. We will discuss the implications of this assumption further below.

C. The Effective Tax Rate and the User Cost of Capital, More Broadly Defined

For developed economies such as Japan and the United States, the major effects of policy on the incentive to invest may well come through the tax system. Hence, the use of the various effective tax rate measures already discussed may suffice. In developing countries, the most important effects of policy may not work through the tax system at all, or may do so indirectly, rather than through capital income taxes.

In terms of the user cost of capital expression on the right-hand side of (14), we may distinguish between policies that affect the price of capital goods, g, the required rate of return, r, the output price p and the productivity term θ, through the effective real wage w/p or the effective cost of material inputs v/p.

Policies affecting g and r may be seen as the equivalent of capital income taxes, since they influence the gap between the gross and net returns to capital. Put another way, they appear only in the first-order condition for capital, (12), and not those for labor and materials, (6) and (7). For purposes of measuring relative costs of capital and other inputs, one would add only such policies to those previously considered, and the way of doing so is straightforward. However, if one wishes to measure the incentive to invest, then effects on p, w/p and v/p matter, too, since each of these variables appears on the right-hand side of (14). For example, a subsidy to labor or a protective tariff on an industry's output may well increase investment. While it is misleading to equate such policies with a reduction in capital income taxes, it is important to consider them along with policies directed at capital specifically.

Some examples of how such policies affect the cost of capital defined in (14) follows.

1. **Indirect taxes**

If materials goods face on ad valorem tax rate t_m, then the real materials cost v appearing as an argument of $\theta(\cdot)$ (see (13)), would equal $(1 + t_m)v_w$, if v_w if the price net of tax (subscripted by w to indicate that this will be the world price if other price distortions are absent). Assuming that indirect taxes are not applied to exports, they will have no effect on the expression for the output price p, which will equal the world price p_w.

2. **Tariffs**

A tariff on materials inputs at rate T_m affects the cost of materials to the firm just as an indirect tax would, $v = (1 + T_m)v_w$. However, a tariff at rate T_p an output would raise the output price, relative to the world price, to $p = (1 + T_p)p_w$. As is well known, this output price effect is equivalent to a _general_ production subsidy to the firm.

3. Dual Exchange Rates

If there is a controlled and an uncontrolled sector in the exchange market, we may treat the difference between the two exchange rates as a general trade intervention. Importers forced to buy foreign currency at the (presumably higher) controlled rate are essentially facing a tariff.

4. Quantity Controls

In general, each type of quantity control has an analogous price distortion. A well-known example is tariff and quotas. In this case, the challenge is to identify the tariff-equivalent of the quota, which requires some assumption about the price-elasticity of demand for the commodity in question.

Other examples of quantity controls occur in the capital market. Here, one can estimate the subsidy inherent in targeted funds by comparing the stated interest rate to the market interest rate, as long as a latter such rate is available. To the extent that such funds are used _at the margin_, the implied subsidy rate should be used to adjust the interest rate appearing in r (see (2)).

5. Imperfect Competition

If firms are not price-takers, this introduces the possibility of a mark-up of the sales price p over marginal cost. The extent of the mark-up will, of course, depend on the nature and degree of imperfection in the product market.

One type of imperfection that is relatively easy to analyze is monopolistic competition, under which each firm faces a downward-sloping demand curve with price elasticity η, where η depends both on the overall elasticity of demand, the number of firms, and the degree to which import substitution is possible. In this case, the firm behaves as if it faces an output price $p\ (1-\frac{1}{\eta})$ rather than p in each of its factor utilization decisions system. The case is analogous to that of production tax at rate $\frac{1}{\eta}$.

In summary, policies affecting the numerator of the right-hand side of expression (14) are capital-related; whether they are capital income taxes as typically included in effective tax rate measures or policies with similar effects, they have equivalent marginal effects to a change in the rate of capital income taxation. In this sense, they are appropriate for inclusion in an accurate calculation of the "effective tax rate" on capital income.

Tax and nontax policies that affect the denominator of the right-hand side of (14) also affect investment and should therefore be considered in any analysis that seeks to measure the full effects of policy on investment. Though significant, their marginal effects differ from those of capital income tax changes, for they also influence the real costs of labor and materials. Moreover, because these polices affect the attractiveness of capital indirectly through the price of output or other inputs, their impact on investment cannot be measured without additional information about the production process. That is, policies that affect p, w/p or v/p all work through the term θ in expression (14), and the form of θ depends on the exact specification of the production function, particularly the degree to which other inputs are substitutes or complements for capital.

For example, suppose the production process requires a fixed ratio of materials to output and that value added by capital and labor is described by a Cobb-Douglas function. Then $X(\cdot)$ has the form:

$$X(K, L, M) = \min(AK^{\alpha}L^{\beta}, M/m) \tag{18}$$

for constants α, β and m, and $\theta(\cdot)$ has the form (dropping time subscripts):[4]

$$\theta(w/p, v/p) = \left(\frac{w}{p}\right)^{-1/(1-\beta)} [1-m(v/p)]^{1/(1-\beta)} \tag{19}$$

In this case, both labor and materials are complementary to capital in the production process: an increase in either the real price of materials or the real price of labor reduces the desired capital stock. The elasticity of the user cost of capital, defined by the right-hand side of (14), with respect to the real wage is $1/(1-\beta)$; the elasticity with respect to the real cost of materials is $m(v/p)/[1-m(v/p)]$. By comparison, the elasticity with respect to the corporate tax rate τ (holding Γ constant) is $\tau/(1-\tau)$.[5] (For more general specifications of production, it will not even be possible to express $F(\cdot)$ in the separable form given in (13) and the term θ can only be locally approximated).

Up to this point, all policies discussed have worked in markets with fixed world prices. Policies driving a wedge between such world prices and the prices facing the firm translate directly into changes in the user cost of capital. One must add the marginal burden of capital income taxes to the net returns required by suppliers of funds. Likewise, the domestic prices for output and inputs, p and v, equal the world prices plus any tariff or tariff-equivalent quantity restriction, such as an import quota, that is imposed domestically. Unlike in a closed economy, no general equilibrium calculations are necessary to estimate how much the gross return or price rises with the tax. This makes the resulting effective tax rate more directly informative about the user cost itself.

This simplicity is absent for labor market interventions, since (for most countries) labor is not nearly as mobile as capital. Thus, one cannot immediately compute the impact on the real wage rate and hence the user cost of capital of tax and nontax policies that drive a wedge between the real wage received by workers and the cost of labor facing firms. Incorporating the gap between gross and net wages in a grand "effective tax rate" computation may, as a result, be extremely misleading if the incidence of labor income taxes falls largely on workers rather than firms.

D. Summary

If one wishes to estimate the effects of tax policy on the incentive to invest, the augmented user cost expression given in (14) provides a sufficient statistic, given the modelling assumptions adopted in this section. Traditional measures of the "effective tax rate" on capital fail in several respects to provide an equally useful measure.

First, they typically ignore the separation of saving and investment decisions and the importance of international capital flows. Second, they consider only explicit taxes on capital and capital income, ignoring both nontax capital policies (such as targeted lending) and tax and nontax policies, such as tariffs and quotas, that indirectly influence the incentive to invest through their effects on the prices of outputs and other inputs. Finally, in emphasizing the magnitude of the tax wedge between gross and net returns to capital, rather than the level of the gross return, a given effective tax rate can correspond to several different levels of the desired capital stock, depending on the incidence of the taxes in question. A given tax wedge added to a price that is fixed in world markets may reduce investment more than were the price determined domestically.

While the analysis to this point represents a useful summary of much of the literature to date, it is static in nature. It therefore ignores the dynamics of the investment process, a specification of which is necessary for empirical work on investment. The characterization of the investment process itself can be particularly important in cases where changes in the tax system are being considered.

III. Changes in Tax Regime

Over time, the economic conditions affecting investment may change quite markedly. Among these economic changes are shifts in tax regime, caused not only by policy shifts affecting all firms but also by shifts in an individual firm's tax status. For example, a firm may face a zero marginal tax rate on its taxable income for a period of years because it is carrying a large stock of losses and depreciation allowances forward, and then become taxable once again as these deductions expire or are used up. Both types of change in tax regime, economy-wide and firm- or sector-specific, can exert a powerful, if temporary impact on investment incentives. Indeed, in an unstable economic environment, such "temporary" effects may nearly always be present. Thus, one should go beyond examinations of tax systems applicable only in a "long run" which is unlikely ever to occur.

Once one admits the importance of changes in economic conditions, the assumption of instantaneous capital stock adjustment made above becomes even more restrictive. It is clear that firms will not cause their capital stocks to swing wildly in response to each instantaneous change in the user cost of capital. To model investment behavior realistically, therefore, it is necessary to replace this assumption. The introduction of convex adjustment costs for the capital stock provides such a smoothing incentive.[6] The following analysis follows closely that first presented in Auerbach (1989). For the interested reader, the full derivation is provided in the appendix. An empirical application for the United States may be found in Auerbach and Hines (1988).

We begin again with a firm seeking to maximize its value as in (11), but introduce two changes. First, the tax parameters may vary over time, so that, in particular, τ, k and hence Γ require time subscripts. For the moment, we continue to assume perfect certainty about these tax changes and the absence of any risk. Second, we replace the exogenous price of capital goods g with a total cost $g(1 - \delta\phi K + \frac{1}{2}\phi\dot{K})$, chosen to give rise to a simple expression for the marginal cost of capital goods:

$$(20) \qquad q = d(g[1 - \delta\phi K + \tfrac{1}{2}\phi(I-\delta K)]I)/dI = g(1 + \phi\dot{K})$$

The term the ϕ is an adjustment cost parameter, equal to the percent increase in effective capital goods prices to the firm per unit of additional investment.

Replacing g in (11) with q as defined in (20), and adding subscripts to the tax parameters, we obtain the following Euler equation for the firm, replacing (12):

$$(21) \qquad F_t'(K_t) = \frac{q_t\ (r+\delta)(1-\Gamma_t)/p_t\ -\ [q_t(1-\Gamma_t)/p_t]^{\bullet}}{(1-\tau)}$$

where the after-tax present value of investment incentives is:

$$\text{(22)} \qquad \Gamma_s = k + \int_s^{\infty} \tau_t e^{-(r+\pi)(t-s)} D_t(t-s)\, dt$$

Expression (21) is no more than a user cost of capital that takes explicit account of expected changes in the real, after-tax relative price of capital goods $q(1-\Gamma)/p$ (Auerbach 1983b). However, since q is a function of investment itself, (21) is a first-order condition only rather than a direct solution for K. To obtain the latter, one must substitute the expression for q given in (20) into (21), obtaining a second-order differential equation in K that must then be solved. Because this equation is nonlinear, a closed form solution will not generally be available. However, such a closed form solution may be derived if one linearizes the differential equation around its steady state solution.[7] The solution for investment may be expressed as a model of partial adjustment toward a "desired" capital stock:[8]

$$\text{(23)} \qquad I_t = (-\sigma_1)(\hat{K}_t - K_t) + \delta K_t$$

where the desired capital stock satisfies:

$$\text{(24)} \qquad G'(\hat{K}_t) = C_t = \int_t^{\infty} \sigma_2\, e^{-\sigma_2(s-t)} c_s\, ds$$

the instantaneous cost of capital term c_t equals

$$\text{(25)} \qquad c_t = \frac{g_t[(r+\delta)(1-\Gamma_t) - (1-{}^{\Gamma_t})]}{\theta_t p_t (1-\tau_t)}$$

and the terms σ_1 (≤ 0) and σ_2 ($\ge (r+\delta)$) are the roots of the second-order differential equation.[9] (As before, the function $G(\cdot)$ is defined in expression (13) as the production function divided by the term θ.)

Because the weights $\sigma_2 e^{-\sigma_2(s-t)}$ sum to one, we can view expression (24) as indicating that the desired capital stock that influences investment at date t depends on a weighted average, C_t, of present and future user costs of capital. Only if adjustment costs are zero and hence adjustment is instantaneous (in which case $\sigma_2 = \infty$) or if the cost of capital is constant over time will the current cost of capital be sufficient to describe the effects of the tax system on investment. In general, forward looking investment behavior that depends on the weighted average of current and future costs of capital may be quite different from that implied by assuming a constant cost of capital without changing tax rates. The use of this new methodology is straightforward. It differs from traditional specifications primarily in its dependence on predicted <u>future</u> capital costs rather than lagged ones. To apply it, one first calculates the instantaneous user cost of capital at each date t, c_t, and then aggregates these user costs over all future dates. The weights to use in this aggregation depend on a number of parameters (see footnote 9), not all of which are precisely known (such as $\emptyset$). Hence experimentation with different weighting scheme seems called for. In the first step, one must allow for potential changes in the tax rate τ when calculating Γ, and must also allow for potential changes in Γ itself.

We now provide some examples to illustrate this approach. It is helpful in making these examples realistic to draw them from the policies and experiences of particular countries. However, such examples should not be interpreted as an overall evaluation of the tax policies of the countries in question.

A. **Changes in tax structure**

Many countries have recently enacted tax reforms aimed at broadening the tax base while at the same time lowering tax rates. The effects on investment of the 1986 U.S. reform are discussed in Auerbach (1989).

Among developing countries, Mexico has recently moved to an indexed corporate tax system, with a phased reduction in the corporate tax rate from 42% to 35%. During the transition period, the tax rate reduction itself has three effects on the instantaneous user cost of capital given in expression (25). First, it reduces the tax rate term appearing in the denominator, lowering the cost of capital. Second it reduces the after-tax present value of depreciation deductions, Γ (calculated using (22)), increasing the cost of capital. Third, it makes $\dot{\Gamma}$, the time derivative of Γ, negative: the present value of depreciation deductions declines over the period as the tax cut is phased in. This last effect reduces the user cost: there is an incentive to invest while depreciation allowances may still be deducted at the higher tax rate. On balance, the instantaneous user cost, as well as the weighted average of current and future such user costs relevant to current investment, will likely fall, stimulating investment.[10] It is even possible that investment will be stimulated more by a phased reduction in the tax rate rather than an immediate one, since the anticipated decline in the value of Γ, by itself, stimulates investment.[11] This possibility emphasizes the distinction between average and marginal tax rates, between the level of taxes paid by a company and its incentive to invest. A delayed reduction in the tax rate τ will certainly cause the firm to pay more taxes in the short run, even in it faces a lower cost of capital and hence invests more.

A similar distinction may be made between the effects of investment-oriented incentives, such as investment tax credits and allowances, and cuts in the tax rate τ. While both will spur investment, rate reductions will reduce tax payments by more, given the level of investment stimulus, because they will also reduce the taxes the firm pays from sources of income other than new investment, including existing capital and economic rents.

B. Tax holidays

Many countries provide tax holidays to attract new investment. Tax holidays provide the investing firm with an exemption from tax on its normally taxable income during some time period after the firm's initial investment is made. As discussed in Mintz (1989), such a holiday does not necessarily imply that the firm's user cost of capital is the same as it would be in the absence of taxation, since the holiday is not permanent. In considering whether to invest, the firm must calculate the taxes it will pay on today's asset purchase once the holiday is over, as well as the tax incentives to invest at a later date. Neither of those factors would apply if the holiday were permanent, for all present and prospective investments.

The problem of tax holidays can be analyzed in exactly the same manner as the "global" tax rate change just considered. The situation is the same as if the firm faced a zero tax rate for a predetermined length of time, followed by the normal rate of tax τ, thereafter.

Once again, there are three effects on the instantaneous user cost of capital during the holiday period. The tax rate at the current date is zero. To the extent that the depreciation allowances on the firm's current investment extend beyond the holiday period, the present value of after-tax depreciation allowances Γ would be reduced but not eliminated.[12] Finally, the time derivative of this present value, $\dot{\Gamma}$, would be positive, since the fraction of allowances deductible from tax would rise as the end of the holiday period approached. The first impact would be positive, the second and third negative. The impact on investment during the holiday period would depend on the generosity of the investment incentives themselves. It is entirely possible that some types of investment would be discouraged. This would be most likely in cases where the initial investment allowances were larger than concurrent cash flow. In such cases, new investments would generate a negative tax base in the years immediately after an investment, so firms would actually benefit (with respect to their new investment) by being taxable. See Auerbach (1983a).

The revenue cost of a tax holiday depends on whether it applies to assets already in place. If it does then, like a permanent tax rate reduction, the tax holiday reduces the taxes that firms pay during the holiday period on preexisting sources of income other than the new investment that the policies aim to encourage. This makes the tax holiday more costly than more targeted investment incentives, such as investment tax credits or grants.

C. Tax law asymmetries

Most countries allow firms with net operating losses to carry these losses forward, to be used to offset subsequent taxable income. Some countries also allow losses to be carried back, providing refunds against taxes previously paid. Firms that are currently not paying taxes but with some probability will be doing so in the future can be treated as if they are facing a tax regime with marginal tax rates that change over time. In this sense, the case is similar to the previous one of tax holidays. However, in this case, one cannot simply assume a current marginal tax rate of zero for a firm that is not presently paying taxes. In present value, additional income earned today may well lead to a significant tax liability, even if no taxes are paid immediately.

For example, suppose a firm has a tax loss this year, which it will carry forward and, with certainty, use up next year, when it will be paying taxes once again. If the firm generates another dollar of income this year, this income will reduce the tax loss carried forward by one dollar. This reduction, in turn, will increase by one dollar the firm's taxable income the following year, since the size of the deductible tax loss will be smaller. Hence, the firm will pay taxes on an additional dollar of income with a one year delay. The true marginal tax rate for the current period, which one may think of as a "shadow" tax rate, is therefore the statutory rate, τ, discounted for one period at the nominal interest rate.

Of course, one cannot be certain of the date at which a firm not currently paying taxes will begin doing so, but this does not pose a conceptual problem for the application of the preceding methodology. If one can estimate a probability distribution of when a firm will begin paying taxes again, one can simply multiply the tax rate for each date by the associated probability and add the discounted values of these products together to obtain today's shadow tax rate. Doing so for each date, one can produce a time profile of shadow tax rates for a given firm, which can then be used to calculate the user cost of capital.

Illustrations of this approach are presented in Auerbach (1983a), Auerbach and Poterba (1987) and Altshuler and Auerbach (1989). It can be applied even in cases where firms are permitted to carry losses back, and where different rules for carrying forward apply to different components of taxable income. In the United States, for example, the rules for carrying forward unused investment tax credits have differed from those applying to ordinary losses. In other countries, such as Pakistan, net operating losses exclusive of depreciation allowances can be carried forward for only six years, while unused depreciation allowances themselves can be carried forward indefinitely. Hence, the shadow tax rate applicable to depreciation deductions should be closer than the shadow tax rate applicable to ordinary income to the statutory tax rate. In Mexico, the value of losses carried forward is indexed for inflation. Therefore, the deferral of tax payments should be discounted by a real rather than a nominal interest rate when computing shadow tax rates.

The importance of allowing for tax losses and related asymmetries depends on the empirical significance of such phenomena. In the United States, for example, Altshuler and Auerbach (1989) estimated that firms faced an average marginal shadow tax rate of 32% in the early 1980s even though the statutory marginal tax rate during the period was 46%. The importance of tax losses has been demonstrated for Canada as well (Mintz 1988).

As with tax holidays, a temporary respite from taxes induced by tax loss carryforwards can have complicated effects on the incentive to invest. If a program of generous investment incentives is in place, investment by firms that are not paying taxes may actually be discouraged. In such situations, alternative forms of investment incentives may be desired, such as direct grants that do not work through the tax system.

D. <u>Uncertainty and risk</u>

As the discussion of tax law asymmetries illustrates, uncertainty about the tax regime a firm will face in the future may exert a significant impact on its current investment. A realistic treatment of the effects of tax policy must also account for the uncertainty that firms will attach to government policy itself. Countries without an established reputation for following through on announced policies may face difficulties making investment incentives effective. The possibility of dynamic inconsistency on the part of governments has played a role in past discussions of the design of tax policy, suggesting why generous tax holidays might be necessary to attract foreign investment (Doyle and van Wijnbergen 1984).

This issue has several implications for the cost of capital specification. First, anticipated tax rates that appear in the cost of capital expression should not necessarily be those listed in government documents. One must allow past behavior to inform the determination of such tax rates. Second, the efficacy of a tax policy should be judged with respect not to its announced changes, but rather the changes it induces in the policy anticipations of investors. One policy may appear more stimulative than another, but may be found to be less plausible or permanent. For example, a promised reduction in the tax rate τ may be reversed or postponed more easily than an investment tax credit already given today can be taken back from the taxpayer in the future (Hansson and Stuart 1989). Finally, the uncertainty with respect to tax policy may cause risk-averse investors to demand a risk premium, a higher rate of expected return. Hence, a climate of uncertainty about tax policy may, in itself, discourage investment. More generally, risk is a central aspect of the investment process. Even with a riskless tax environment, investors may be subject to considerable uncertainty about the future profitability of their prospective investments, and may as a result demand an expected rate of return considerably in excess of the risk-free interest rate. The required rate of return r that appears in the user cost of capital expression (25) derived above must reflect this risk premium. Likewise, the rate of discount applied to future depreciation allowances must account for any risk associated with such tax benefits. Indeed, there is nothing requiring that the discount rates appropriate for tax benefits and other after-tax flows be the same. While such differences may be easily accommodated in the cost of capital calculation, they make standard effective tax rate calculations based on a uniform rate of return inappropriate and potentially quite misleading (Auerbach 1983a). The discount rates applicable to future tax benefits are especially important in the design of tax incentives.

IV. Institutional Factors: Calculating Γ and r

To implement the model of investment behavior derived in the previous section, one must incorporate the relevant tax and nontax provisions affecting the firm's required rate of return r and the present value of its investment incentives, Γ.

A. Measuring investment incentives

Most countries provide schedules of straight-line or declining balance depreciation allowances. Such schedules may be extremely accelerated relative to actual economic depreciation. Turkey, for example, provides a 50% declining balance depreciation rate for equipment. However, these allowances are typically not indexed for inflation, and so must be discounted using a nominal discount rate. Mexico has recently introduced the choice of a one-time, first-year deduction, in lieu of all subsequent depreciation allowances, that is meant to provide roughly the present value of such depreciation allowances and protect them from inflation.[13]

In addition, many developing countries provide initial relief for investors over and above normal depreciation deductions. In Turkey, for example, there are investment allowances of 30% to 60% for certain types of investment. In Pakistan, the initial allowance for machinery and equipment is 40%, with the allowance deducted from the basis used for subsequent depreciation.

Other investment incentives do not fit as directly into the expression for Γ given above, but may be expressed in equivalent terms. For example, the value of a subsidized loan associated with a particular investment may be computed by estimating the present value after-tax of the interest and principal payments made on the loan and subtracting this from the face value of the obligation, i.e. the amount of money initially provided to the investor.

A somewhat more complicated investment scheme is the "investment fund" or (as it is referred to in Turkey) "financing fund" system. Such a scheme provides firms with a tax deduction for setting funds aside in the investment fund. The funds may subsequently be drawn down for the purpose of making investments. Their use in Sweden has been the subject of previous discussion in the literature (e.g. Taylor 1982, Södersten 1988).

In Turkey, firms may contribute up to 25% of their taxable profits to the fund in a given year and receive a deduction for doing so. The funds are deposited in a government bond account at the central bank, and may be drawn down to the extent of new investment in the future. However, the firm must add the contributed funds back into taxable income one year hence, so that it receives a one-year tax deferral on the contribution regardless of how long the funds remain in the account. Balancing the benefit associated with this tax deferral may be the cost of keeping funds in an account yielding what may be a below-market interest rate. Even if a net tax benefit remains, a serious question remains about the efficacy of such a program in stimulating investment.

The problem with investment fund schemes is that the tax benefit may well be unrelated to the marginal investment decision. If firms are investing at least a quarter of their earnings anyway (this is not an especially high rate of reinvestment), then the scheme in practice is equivalent to one that simply gives firms a one year tax deferral on a quarter of their earnings in exchange for placing these earnings in a government account for a year. While this scheme may benefit the firm, it does not provide any subsidy to new investment. It encourages investment only in the sense that it reduces the effective tax burden on 25% of the future earnings that such investment generates, in precisely the way that a very small reduction in the rate of income tax τ would.

B. Measuring the required rate of return

There are several issues relating to the measurement of the required rate of return r. Already discussed above is the need to use realistic rates of return that reflect the risk premia required by the market. In an economy with well-developed financial markets and most investment undertaken by public corporations, the required nominal return to debt i in expression (2) would be well approximated by the observed nominal interest rate, and the required return to equity before personal taxes, $\mu/(1-\Phi)$, could be based on observed returns to equity. One could use either an after corporate tax earnings-price ratio or a market return (dividend yield plus capital gain) for this purpose. A benefit of this approach is that it may not require one to specify the tax treatment of those who supply the funds to corporations.[14]

In a developing country, such returns to debt and equity may not be as easily observable. In this case, one may need to use information on world interest rates, combined with the tax rules that apply to foreign source capital income. For example, suppose the U.S. interest rate is i^*. An American investing in foreign debt must pay whatever taxes are withheld abroad on the repatriated interest income, plus U.S. taxes net of any allowable foreign tax credit. (If the foreign taxes are fully creditable, then the U.S. investor bears only his U.S. tax rate on the interest received.) Let t_p be this U.S. tax rate. Then the investor's net return in the U.S. will be $i^*(1-t_p) - \pi^*$, where π^* is the U.S. inflation rate. Assuming that exchange rate gains and losses are not taxable, the dollar rate of return available abroad will be $i(1-t_{max}) - \pi - d$, where i is the foreign nominal interest rate, t_{max} is the higher of t_p and the rate of withholding tax, π is the foreign inflation rate and d is the rate of foreign currency depreciation against the dollar.

Equating these two net rates of return yields:

$$(26) \qquad i = \frac{i^*(1-t_p) - (\pi^* - \pi - d)}{(1-t_{max})}$$

In cases where the liability is denominated in dollars, the term $(\pi^* - \pi - d)$ vanishes because all transactions are in the same currency. (The term will also vanish if purchasing power parity is satisfied.) If, in addition, taxes withheld are fully creditable, then $t_{max} = t_p$ and $i = i^*$. More generally, however, both of these sources of difference between i and i^* will be present. The low rates of income tax now in effect in many developed countries (including the United States), may in some cases be exceeded by foreign rates of withholding tax on interest. For example, while the top tax rates in the United States are 34% for corporations and 33% for individuals, Mexico withholds 42% of interest payments. Further, some countries follow the territorial approach to taxation and offer no credit at all for foreign taxes withheld. Even after one allows for the effects of these tax provisions, it is still necessary to account for differences in risk among countries that would be reflected in required rates of return after-tax. However uncertain one is about the size of such risk premia, expression (26) is still useful because it shows how changes in the domestic withholding tax rate affect the cost of capital, given the level of risk.

Computing the required return to equity by using rates of return observed abroad is even more problematic than in the case of debt. First of all, since equity normally bears a considerably greater fraction of investment risk than debt, the problem of measuring risk premia is more significant in this case. Second, the tax treatment of equity investment from abroad is more complicated than the treatment of debt. The effective rate of tax depends not only on the rates at which taxes are withheld and credited, but also on whether the funds come from another corporation via foreign direct investment or from the household or banking sector, and whether the equity funds for investment abroad come from earnings retained from existing projects abroad or new equity contributions from the investing country (see Hartman 1985, Gordon 1986). A comprehensive discussion of this problem is beyond the scope of this paper. However, one may cite some basic results that are helpful in guiding the specification of the required return to equity.

Consider the case of foreign direct investment, in the "host" country. Let $\nu = \mu/(1-\Phi)$ be the required return to equity in the country from which the funds come, the "home" country, and ignore for the moment differences in risk. If such funds are sent abroad and all their earnings repatriated, the rate of return after taxes in the host country must equal ν plus any additional taxes imposed in the home country upon repatriation, net of foreign tax credits. If

t_f^* is the foreign tax rate imputed by the home country for such receipts from abroad, and t_c^* is the home country's corporate tax rate on repatriated earnings, then the required return to equity abroad after foreign taxes will be $\nu(1-t_{min}^*)/(1-t_c^*)$, where t_{min}^* is the smaller of t_f^* and t_c^*. If the foreign tax rate used when imputing the credit (typically not the statutory tax rate τ but some estimate of the presumably lower effective corporate tax rate in the host country) is at least as high as the home country's tax rate on foreign earnings, t_c^*, then this required rate is just the rate of return required at home, ν: no further corporate taxes will be owed in the home country. If additional taxes are due on repatriated earnings, however (this will never be the case for home countries following the territorial approach, where $t_c^* = 0$) then the required return to equity will exceed ν.

When foreign direct investment is funded by retained earnings already in the host country, however, the calculation of the required return to equity ν is simpler. In this case, the tax treatment of repatriated funds is irrelevant, since repatriated funds will bear the same rate of tax and, in present value, the same tax burden regardless of when they are repatriated (Hartman 1985). Thus, the required rate of return will always be ν. Therefore, for countries with tax rates sufficiently high to provide enough foreign tax credits to offset further corporate tax liability upon repatriation, the required rate of return to equity after corporate taxes (except for differences in risk) will be the required rate of return to equity in the countries supplying the investment funds.

Thus, for both debt and equity, the major difficulty involved in estimating the firm's required return is the estimation of the domestic risk premium.

V. Conclusions

This paper has reviewed the literature on investment and the cost of capital, showing how the effects of tax and nontax government policies should be incorporated in the analysis of investment behavior. The methodology is in several respects more general than calculations of tax wedges and effective tax rates. Its application in a developing-country context should provide light on the ability of policy to influence investment, the efficacy of those policies currently being pursued, and the appropriate directions for reform.

Table 1

Notation

$X(\cdot)$	-	general production function, with capital, labor and materials as arguments.
$F(\cdot)$	-	residual production function, with capital as an argument, obtained by subtracting labor and materials costs from $X(\cdot)$ and solving for labor and materials as function of K. (defined in equation (10)).
$G(\cdot)$	-	residual production function normalized for fluctuations in the profitability of capital (defined in (13)).
θ	-	term representing the fluctuation in the profitability of capital due to variation in input prices. (defined in (13)).
δ	-	capital depreciation rate (geometric).
i	-	nominal interest rate.
b	-	debt-value ratio.
π	-	inflation rate.
μ	-	required real after-tax return to equity holders.
ν	-	$=\mu/1-\Phi$ real required return to equity, before personal taxes.
n	-	real return to bondholders after tax (defined in (16)).
r	-	weighted average cost of capital (defined in equation (2)).
p	-	output goods price.
p_w	-	world output goods price.
v	-	material goods price.
v_m	-	world material goods price.
g	-	capital goods price.
q	-	capital goods price, including marginal adjustment costs.
$\emptyset$	-	adjustment cost parameter.
w	-	nominal wage rate.
Φ	-	effective household tax rate on equity income.
k	-	investment tax credit.

$D(a)$ - depreciation deduction for a capital good of age a.

Γ - present value of investment credits and depreciation deductions (defined in equation (3)).

e_c - effective corporate tax rate (defined in (15)).

e_T - effective total tax rate (defined in (17)).

t_p - personal tax rate of bondholders.

T_m - tariff rate on material good.

T_p - tariff rate on output good.

t_m - excise tax on material good.

Appendix

This appendix sketches how the decision rule given in equations (24) and (25) can be derived as a solution of the linearized version of the Euler equation (21).

For simplicity, we normalize the output price, p, to one. First (letting $F_t(K) = \theta_t G(K)$), express (21) as a differential equation in $\dot{q}$:

$$\text{(A1)} \qquad \dot{q} = -\, G'(K)\theta\left(\frac{1-\tau}{1-\Gamma}\right) + q(r+\delta) - q\left(\frac{\dot{(1-\Gamma)}}{1-\Gamma}\right)$$

Linearizing around the steady state (where $q = g$ and $\dot{\Gamma} = 0$), we obtain (letting * denote steady state values):

$$\text{(A2)} \qquad \dot{q} \approx -G''(K^*)\,\frac{(1-\tau^*)}{1-\Gamma^*}\,(K-K^*) + (r+\delta)(q-g)$$

$$-\,\frac{G'(K^*)}{(1-\Gamma^*)}\,\theta^*\,[(1-\tau)-(1-\tau^*)] - \frac{G'(K^*)(1-\tau^*)}{(1-\Gamma^*)}\,(\theta-\theta^*)$$

$$+\,\frac{G'(K^*)}{(1-\Gamma^*)^2}\,[(1-\Gamma) - (1-\Gamma^*)] - g\,\frac{\dot{(1-\Gamma)}}{(1-\Gamma^*)}$$

Using expression (20) for q and the fact that $G'(K\ ) = c^* = g^*\dfrac{(r+\delta)\ (1-\Gamma^*)}{\theta^*(1-\tau^*)}$,

we obtain:

$$\text{(A3)} \qquad \ddot{K}_t - (r+\delta)\,\dot{K}_t - \frac{\alpha(r+\delta)}{\Phi} = -\,\frac{x_t}{\Phi}$$

where $\alpha = -G''/G'$, $x_t = \frac{\alpha(r+\delta)}{\Phi}\,K^*\,[1 - \frac{1}{\alpha K^*}\,a_t]$, and

$$\text{(A4)}\quad a_t = -\frac{(1-\tau)-(1-\tau^*)}{(1-\tau^*)} + \frac{(1-\Gamma^*)-(1-\Gamma^*)}{(1-\Gamma^*)} - \frac{\theta_t-\theta^*}{\theta^*} - \frac{1}{r+\delta}\quad\frac{(1-\Gamma_t)}{(1-\Gamma^*)}$$

The equation (A3) has roots:

$$\text{(A5)}\qquad \sigma_i = \frac{r+\delta \pm \sqrt{(r+\delta)^2 + \frac{4\alpha(r+\delta)}{\phi}}}{2} \qquad i=1,2$$

Solving the unstable root, $\sigma_2 > 0$, forward, one obtains the first-order equation:

$$\text{(A6)}\qquad \dot{K}_t - \sigma_1 K_t = \int_t^{\infty} e^{-\sigma_2(s-t)}\, x_s\, ds$$

which may be rewritten as the partial adjustment model given in expressi .. (23) in the text where $\hat{K}_t = K^* - \frac{\Omega_t}{\alpha}$ and

$$\text{(A7)}\qquad \Omega_t = \int_t^{\infty} \sigma_2\, e^{-\sigma_2(s-t)}\, a_s\, ds$$

By another first-order approximation,

$$\text{(A8)}\qquad G'(\hat{K}_t) \simeq G'(K^*) + G''(K^*)(\hat{K}_t - K^*)$$

$$= G'(K^*)(1 - \alpha(\hat{K}_t - K^*))$$

$$= G'(K^*)(1+\Omega_t)$$

Substitution of (A7) and the value of $G'(K^*)$ into (A8) yields:

$$\text{(A9)} \qquad G'(\hat{K}_t) \simeq \int_t^\infty \sigma_2 \, e^{-\sigma_2(s-t)} \frac{[g(r+\delta)(1-\Gamma^*)}{\theta^*(1-\tau^*)} (1 + a_s)] \, ds$$

However, from inspection of (A4), we observe that a_s is simply the first-order deviation of c_s as defined in (25) from c^*.

$$\text{(A10)} \qquad c_s \simeq \frac{g(r+\delta)(1-\Gamma^*)}{\theta^*(1-\tau^*)} (1 + a_s)$$

Substitution of (A10) into (A9) yields expression (24) in the text.

When there are constant returns to scale in production, $\sigma_1 = \gamma = 0$. Hence, the solution based on (A6) is:

$$\text{(A11)} \qquad \dot{K}_t = -\int_t^\infty e^{-\sigma_2(s-t)} \frac{r+\delta}{\phi} a_s \, ds = -\int_t^\infty \frac{\sigma_2}{\phi} e^{-\sigma_2(s-t)} a_s \, ds$$

$$= -\frac{1}{c^*\phi} \int_t^\infty \sigma_2 e^{-\sigma_2(s-t)} c^* (1+a_s) \, ds + \frac{1}{\phi}$$

$$\simeq \frac{1}{\phi} - \frac{1}{c^*\phi} \int_t^\infty \sigma_2 e^{-\sigma_2(s-t)} c_s \, ds$$

Once again, investment depends on current and future values of the instanteneous user cost of capital, c.

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Footnotes

1. A particular example of a production structure giving rise to F(•) having this separable form is given below.

2. As has long been recognized, a problem arises if the underlying production function X(•) satisfies constant returns to scale. In that case, the derivative of the production function F(•) is not a function of K, so that expression (14) is overdetermined. In this case, the optimal capital stock is either zero, infinite or indeterminate, depending on whether or not (14) is satisfied. It is therefore necessary to assume either decreasing returns to scale in K, L and M, that the capital stock cannot be adjusted instantaneously, or that the firm's marginal revenue curve is not horizontal. The latter two assumptions also make the characterization of the firm's decision more realistic. This is discused further below.

3. One could also assume equal before-tax returns (the "fixed-p" case) or equal intermediate returns (the "fixed-r" case). The problem of choosing among these assumptions is due to the fact that debt and equity coexist even though the tax wedges imposed on debt and equity returns differ. This highlights a limitation of the procedure, its ignorance of risk and other considerations that might help explain observed patterns of financial structure and asset ownership.

4. The whole function F(•) has the form $G(\cdot)\theta(w/p,v/p)$, where

$$G(K) = A^{1/(1-\beta)}\beta^{\beta/(1-\beta)}(1-\beta)K^{\alpha/(1-\beta)}$$

5. Given this formulation, one can readily see the relationship of this discussion to the concept of effective protection. Given fixed world prices p_w for the output good and v_w for the input good, the institution of tariffs T_p on the output good and T_v on the input good causes the term $p\theta$ in the denominator of (14) to equal

$$p_w(1+T_p)\ w^{-1/(1-\beta)}[1-m(v_w/p_w)(1+T_v)/(1+T_p)]^{1/(1-\beta)}$$

If we define T_e to be the uniform tariff that provides the same protection for the industry and hence the same desired capital stock, we obtain:

$$T_e = (1+T_p)\left[\frac{1-m(v/p)\ [(1+T_v)/(1+T_p)]}{1-m(v/p)}\right]^{1/(1-\beta)} - 1$$

which is less that T_p if and only if $T_v > T_p$. The relationship of effective protection to effective tax rates is discussed by Guisinger (1988).

6. Although the result will not be used here, the convex adjustment cost model can also be used to provide a rigorous underpinning for the "q" theory of investment first envisioned by Tobin (1969), under which the firm's investment behavior is related to its market value (Hayashi 1982). Given the market value of the firm, one can then regress investment on the tax-adjusted q ratio of market value to asset replacement cost to obtain estimates of the adjustment cost function (Summers 1981). Unfortunately, this approach does not permit one to measure directly the impact of future costs of capital on investment.

7. An alternative approach, found in Pindyck and Rotenberg (1983), is to estimate the production function and adjustment cost parameters directly from the Euler equation, without solving for the underlying investment rule. That is, instead of solving for an expression for K that is not a function of K, they estimate the Euler equation obtained by substituting (20) into (21) with instrumental variables, treating K as an endogenous regressor. Like the approach of estimating the Euler equation based on (21) alone, i.e., regressing investment on q, this technique does not provide any insight into the effects of future costs of capital on investment.

8. When there are constant returns to scale in production, $\hat{K}$ is either infinite, zero or indeterminate. However, even in the former two cases, the rate of <u>investment</u> will still depend on the costs of capital as defined in (24).

9. Given the formulation of the problem, these roots have the form:

$$\sigma_i = \quad (r+\delta) \; \frac{\sqrt{(r+\delta)^2 + 4\epsilon(r+\delta)/\emptyset}}{2} \qquad i = 1, 2$$

where $\epsilon = - G''/G'$ at the point of linearization. When there are constant returns to scale, $\epsilon = 0$. If, however, the firm faces a downward-sloping demand curve, then the relevant elasticity ϵ would be based on pG rather than G. The negative relationship between price and output would impart more curvature to the marginal revenue product $\frac{d(pG)}{dK}$. Even with $G'' = 0$, there would still be curvature in the revenue resulting from additions to the capital stock.

10. A full analysis of the Mexican reform would be considerably more complicated, for it would require inclusion of the program's other changes, notably the effects indexation of depreciation allowances and interest payments. The former effects would be incorporated via the allowances $D(\cdot)$ in the calculation of Γ and Γ using (22), and the latter would be treated through induced changes in the corporate cost of funds r.

11. For further discussion, see Auerbach (1989).

12. This assumes that the firm cannot defer depreciation allowances occuring during the holiday period. If they can, there would be a much smaller decline in Γ, due only to the discounting of these delayed deductions. In such a

case, the incentive to invest during the holiday period would be much greater as Γ would be larger and Γ smaller. See Mintz (1989) for further discussion.

13. Such a scheme, and its advantages, is discussed in Auerbach and Jorgenson 1980.

14. This simplicity is based on the "q = 1" assumption that a dollar invested by the firm costs shareholders a dollar and that a dollar of earnings is worth a dollar to shareholders whether distributed or not. Under the "tax capitalization hypothesis, the ratio of shareholders' value to firm value, q, may be less that one, equal to the ratio of the after-tax proceeds of a dollar distributed to those of a dollar retained by the firm. In this case, an appropiate measure of equity cost based on observed earnings would multiply these earnings by q. (see Auerbach 1983b), to offset the multiplication by q already implicit in the firm's value. To make this correction, however, one would have to know the tax rates of the "representative" shareholder.

Whether the "q = 1" or "tax capitalization" view depends on the firm's marginal source of funds. If the firm finances its marginal investments using retained earnings, it faces a lower cost of capital because a dollar of funds retained does not cost taxable investors one dollar. There may be other reasons why firms face a lower cost of capital when using internal funds, for example because of information asymmetries. One way if identifying which equity regime a firm is in is by the level of its internal funds. Within the cost of capital framework, one could posit that some function of cash flow determines the appropiate adjustment to observed earnings-price ratios (i.e., whether to multiply earnings by some value of $q < 1$.) An alternative, more ad hoc approach, has been to put cash flow separately into the investment equation. Doing so has recently been found to be quite significant in explaining the investment behavior of smaller U.S. firms (Fazzari, Hubbard and Petersen 1988).

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